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BENEFITS OF CONNECTING RFID AND LEAN PRINCIPLES IN HEALTH CARE

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Abstract

The performance management process in health care is far behind compared to the manufacturing and service industries. Although nowadays the health care organizations are able to deal with a greater rank diseases, their cost, quality and delivery has essentially not improved significantly, and the difference with the other industries even seems to have increased.

As opposed to this situation health care has a tremendous opportunity to deploy lean principles to reduce internal/external costs, improve patient safety, increase profits, reduce litigation and decrease the dependence on Government and Insurance.

The application of these principles is being facilitated by the use of the new technologies. A new technology allowing personnel to constantly "see" what's happening with regards to patients schedule, backlog, workflow, inventory levels, resource utilization, quality, etc., is Radio Frequency Identification (RFID).

The aim of this paper is to analyse the benefits that can be derived from the joint use of lean principles and RFID technology in health care.

Key words: Lean manufacturing, RFID, Wastes of Health care

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1. Introduction

Recent years have seen Health Systems undergoing tremendous transformations. Technological development and modern medicine practices are amongst the outstanding factors triggering this shift [1, 2]. Developed societies face how their population is changing from a predominantly youth-driven marketplace to a middle- and older-aged marketplace. This trend is resulting in a greater demand for health care-related products and services and greater competition among health care providers.

The *Quality Crusade*, the *Green Imperative*, *Corporate Social Responsiveness*, among other recent widely spread managerial approaches, have contributed to the emergence of a new generation of patients, which are enormously conscious of their rights and responsibilities. So far, patients are not quiet and silent anymore, but rather active on choosing doctors, hospital, medical treatments, and the like [3, 4]. As quoted in [5]:

"*The world has changed for surgeons. There was the time when the very sick, with no other hope would go "under the knife" and be grateful for anything that could be done to save their lives or to relieve their symptoms. Surgery is no longer heroic and desperate. People expect a low risk, a high probability of success, and accountability if anything goes wrong. In some ways it is paradoxical that as surgery offers more reliable results it is more often criticised and is under closer scrutiny. That is the way it is".*

Furthermore, we should not forget the Globalisation trend. Globalisation affects almost all human activities. Traditionally, health care is a local matter. In the 21st century, opportunities for global expansion abound. True universal health care would mean that every human on the planet has access to excellent care. In 1999, more than 70 million people turned to the Internet to search for information about health and health care [6]. This number will grow as more people include the World Wide Web in their decisions about health, wellness and medical care. Health and health care are certainly building blocks for the enhancement of life quality and subjective well being Hospitals have taken note of this trend towards online health care by adding web sites to their marketing programs. The percentage of hospitals with web sites grew from 12% in 1995 [7] to more than 50% by 1999 [8]. However, recent data from the American Hospital Association (AHA) Guide indicate that the presence of web sites still varies a great deal across states and types of hospitals [9]. Of course, the Internet also enhances opportunities for global communications and/or the delivery of services in a way that defeats traditional limitations on physical distribution; as it is well known, many health care products consist of knowledge (e.g., a doctor's diagnosis), and such knowledge can be delivered via the Internet in ways that many physical products (e.g., a prescription drug) cannot. Nonetheless, there are also e-pharmacies that challenge the success and market domination currently enjoyed by bricks-and-mortar enterprises.

Health care is such an important segment of the economy and such a key component of human welfare that society and its institutions are willing and able to commit an almost unlimited amount of resources to explore and improve the system. Substantial financial resources have been allocated to the health care sector in recent years. According to a study in 1999, health care spending in the United States totalled \$1.2 trillion and accounted for 13.3% of the gross domestic product [10]. On the other hand, cost containment in the hospital sector is a key issue in stabilizing health cost at a sustainable level [11, 12]. Despite efforts at controlling hospital costs, empirical evidence shows that constant dollar per capita spending on hospital inpatient care rose by 53% between 1980 and 1993 [13]. Further, during the same period, real per capita spending rose by 65% for all types of hospital care and more than 87% for all health services.

Efforts to enhance service, quality and efficiency have over the past decade gained momentum on all levels of government - and performance measurement is being promoted not only in the health care sector but also in the entire public administration sector. Assessing the efficiency impact of government programs (e.g., health care reform) and service providers (e.g., hospitals) is thus being studied with increasing intensity [14, 15]

There is a great potential to improve performance, accountability, and responsiveness by implementing systematic performance evaluation and by integrating performance information into regular policy and public management processes. There are mainly two reasons for the impetus to implement performance measurement systems. First, performance dependent measures of budget allocation, granting, and contracting can be established, which will allow for a competition for financial resources. A second reason is an alignment concerning quality and efficiency of the provision of similar or homogeneous services by improving the accomplishment of the several providers. Analysing the operations of best performing "reference providers" offers insights that assist policymakers and policy evaluators to identify strategies on how to affect increases in performance.

Achieving a high operational efficiency is an essential goal for organizational performance evaluation. This is no exception in the health care sector. Efficiency uses to be considered as the primary indicator of hospital performance [16]. From a managerial perspective, understanding the cost structure of hospitals and their inefficiency in utilizing resources is crucial for making health care policies and budgeting decisions. Higher operational efficiency of hospitals is likely to help control the cost of medical services, and consequently to provide more affordable cares and improved access to the public [17].

Most hospital work processes contain tremendous waste (non value-added activities). One reason for this much waste is that *how* processes should ideally work is rarely specified clearly in health care operations, creating inconsistency in care, unreliable delivery systems, and constant caregiver interruptions. These in turn create inefficiencies, higher operating costs, increased potential for errors and worker frustration [18]. The *Lean manufacturing* represents a fresh way to look at work systems within health care. The term was coined because this system for producing manufactured goods obtained higher quality output at half the cost in half the time of traditional manufacturing methods.

The application of Lean manufacturing in health care can be supported and triggered by the simultaneous incorporation of new information technologies, such as Radio Frequency Identification (RFID). This technology has proven to be very useful when the main purpose is to simplify and improve the service delivery process. Amongst the cases were RFID has been successfully integrated in the health care environment, those most outstanding are the initiatives related to work flow improvements, maintenance of medical equipment, patient's identification, drug's procurement and administration, and inventory management. The main benefits from using RFID have been the improvement of patients' care; together with as remarkable costs reductions and assets utilization.

We begin with a brief discussion of how emerging service operations management theories and practices, such as the lean services approach to health care management, can benefit from the development of new technologies like Radio Frequency Identification (RFID). Understanding the nature of such powerful tools and the changes they portend is critical in grasping the implications they hold, and the new questions they raise for higher efficiency and effectiveness levels.

2. Lean Manufacturing

Lean manufacturing has been described as a philosophy, a perspective that abhors waste in any form, relentlessly strives to eliminate defects, and continually attacks both in a never-ending pursuit of perfection. Very soon most descriptions of lean manufacturing quickly move beyond the philosophical to an interrelated set of practices that range from overall material flow in the factory to detailed work and equipment design to human resource practices [19, 20, 21, 22, 23, 24]. Ongoing research [25] at Montana State University and Community Medical Centre in Missoula, Montana, has adapted several key tools and principles from Lean Manufacturing to health care, and demonstrated their effectiveness in improving hospital operations. Accordingly to that research, Toyota's notion of "ideal" fits health care so well we adapted it as shown in Figure 1.

IDEAL
_ Exactly what the patient needs, defect free.
_ One by one, customized to each individual patient.
_ On demand, exactly as requested
_ Immediate response to problems or changes.
_ No Waste
_ Safe for patients, staff and clinicians: Physically, Emotionally, & Professionally

Figure 1: A notion of ideal for health care [25, 26].

Some of these principles are just introduced in the following paragraphs [25].

- Relentlessly pursue of an ideal state of error-free work [26]. Every change must move the organization closer to this ideal along one or more dimensions; otherwise, the change is not approved.
- Problem solving that happens as close to the event as possible, in specification of the work and clear definitions of "defect free" outcomes makes it readily apparent when defect free does *not* occur (i.e., they do not conform to the ideal).
- Vigilant consideration of the current work systems and evaluation of the ability to produce defect-free, thus driving a production system that changes as soon as a better way is known.
- Process redesigns focus on specifying work activities, making clear connections between those requesting and those receiving goods and services, and simplifying the production pathways of goods and services.

Processes improve and problems become more transparent when activities are specified according to content, sequence, timing, and outcome so that regardless of who performs the work, it is completed in the best-known way with defect-free results. [27]. Processes improve when connections between workers making requests and providing services are direct, simple, and binary—doing so makes them prompt, efficient, and reliable. And, processes improve when goods and services follow the same, simple pathway through the system every time without interruption.

We have summarised in Table 1 some examples of the adaptation of the very well known *"seven wastes of manufacturing"* [19] to the particular circumstances of Health care, in an effort to signal out where waste resides [28, 29, 30, 31, 32, 33, 34].

3. Radio frequency identification (RFID)

Without question, the greatest chances for health care enhancement come from advances in the natural sciences (e.g., biology, medicine and chemistry). However, enhancements may also derive from improvements in the administrative sciences and their related tools, such as those directly linked to Information Technologies (IT). The Internet is an emerging technology that has the potential to revolutionize many aspects of business theory and practice [33, 34]. In a health care context, we might consider some of the following possibilities. First, the Internet can be used to deliver services (e.g., to those in remote areas). In a related vein, mobile commerce (m-commerce) can be used to automate the delivery of life saving drugs and, simultaneously, to alert emergency personnel that there might be a health problem developing [35]. So far, the Internet makes an entire range of new technologies available to hospitals to facilitate communications and build relationships [36]. For instance, a specialized wrist watch could be designed to monitor the wearer's pulse rate, hormone levels or other vital signs. If a threatening situation is detected (by devices in the watch), then the following sequence of events could be initiated. A corrective drug is automatically administered to the wearer of the watch. Appropriate telephone calls are made to the ambulance service, the patient's primary care physician and to the nearest emergency room. This is similar to the case of the Smart Band that the US located Jacobi Medical Center has already started to use. Picture 1 depicts such a Smart Band.

Picture 1: The Smart Band at Jacobi Medical Center: RFID delivers healthy return for hospital. (courtesy of www.rfidjournal.com)

This device constitutes a good example of RFID. The Radio Frequency Identification (RFID) is a method of identifying unique items using radio waves. Typically, a reader communicates with a tag, which holds digital information in a microchip. But there are chipless forms of RFID tags that use material to reflect back a portion of the radio waves beamed at them.

Wastes	Definition	Manufacturing	Health care
Overproduction	Producing more than the customer needs right now	Producing to stock based on sales forecasts Producing more to avoid set-ups Batch process resulting in extra output	Pills given early to suit staff schedules Testing ahead of time to suit lab schedule
Transportation	Movement of product that does not add value	Moving parts in and out of storage Moving material from one workstation to another Moving equipment	Moving samples Moving patients for testing Moving patients for treatment
Motion	Movement of people that does not add value	Searching for parts, tools, prints, etc. Sharing tools, equipments, etc.	Searching for patients, physicians, documentation, supplies, equipments, etc.
Waiting	Idle time created when material, information, people, or equipment is not ready	Waiting for parts, inspection, information, equipments, etc.	Patients waiting for bed assignments, admission to Emergency Dept., testing & treatment, discharge, lab test results
Processing	Effort that adds no value from the customer's viewpoint	Paperwork Over-tight tolerances Awkward tool or part design	Retesting Excessive paperwork Unnecessary procedures
Inventory	More materials, parts, or products on hand than the customer needs right now	Raw materials Work in process Finished goods	Bed assignments Pharmacy stock Lab supplies Specimens waiting analysis
Defects	Work that contains errors, rework, mistakes or lacks something necessary	Scrap Rework Defects Correction	Medication error Wrong patient Wrong procedure Missing information Poor clinical outcomes

Table 1: The seven wastes in Health care

According to [37], Jacobi Medical Centre's RFID-enabled patient ID system not only enhances patient care and staff working conditions, but will also saves $1 million a year when fully deployed. Other example relates to how US located Lucile Packard Children's Hospital uses RFID to track the location of its newest patients and ensure they won't be removed without permission. The same system is being used to track assets. Picture 2 illustrates such a system.

Picture 2: RFID delivers newborns security (courtesy of www.rfidjournal.com)

When private initiatives are considered, some well known examples come to our minds, such as Pfizer plans to place RFID tags on all bottles of sildenafil citrate, or Viagra, intended for sale in the United States by the end of next year. Pfizer estimated that adding RFID to Viagra containers would cost the firm "several million dollars". GlaxoSmithKline (GSK) intends to begin using the technology in the next 12–18 months, i.e., along 2005 and 2006, on at least one product deemed by the National Association of Boards of Pharmacy as susceptible to counterfeiting. GSK products that are "priority candidates" for RFID tags, the company said in a statement, are the very well known Retrovir, Combivir, Epivir, Trizivir, Ziagen, and Zofran— five products that treat HIV infection and one antiemetic [38].

It is very easy to understand that a fundamental aspect of health care management is the effective allocation of resources. This is of particular importance in geriatric hospitals where elderly patients tend to have more complex needs. Hospital managers would benefit immensely if they had advance knowledge of patient duration of stay in hospital. Managers could assess the costs of patient care and make allowances for these in their budget. Besides, clinicians would be able to determine in advance the likely outcome and duration of stay of patients thus enabling hospital managers to make better decisions about the balance of resource allocation, within and between departments. There is no doubt that RFID is a powerful tool enabling hospitals to gather up-to-date and high quality data from patients, medical instrumental, drugs' features and inventories, and so on.

Prior to any further consideration, some technical explanations on the elements that compose the RFID are very much required. In the following paragraphs we introduce summarised explanations for all of them [39]:

> **RFID tag:** It is a microchip attached to an antenna that is packaged in a way that it can be applied to an object. The tag picks up signals from and sends signals to a reader. The tag contains a unique serial number, but may have other information, such as a customers' account number. Tags come in many forms, such smart labels that can have a barcode printed on it, or the tag can simply be mounted inside a carton or embedded in plastic. RFID tags can be active, passive or semi-passive.
>
> **Antenna:** The tag antenna is the conductive element that enables the tag to send and receive data. Passive, low- (135 kHz) and high-frequency (13.56 MHz) tags usually have a coiled

antenna that couples with the coiled antenna of the reader to form a magnetic field. UHF tag antennas can be a variety of shapes. Readers also have antennas which are used to emit radio waves. The RF energy from the reader antenna is "harvested" by the antenna and used to power up the microchip, which then changes the electrical load on the antenna to reflect back its own signals.

Reader: A device used to communicate with RFID tags. The reader has one or more antennas, which emit radio waves and receive signals back from the tag. The reader is also sometimes called an interrogator because it "interrogates" the tag.

RFID tags come in two varieties – **passive** and **active**. Passive tags are powered by the reader's radio waves, and, therefore, the tag must come relatively close to the reader to be activated. Active tags, on the other hand, have a battery in them, and readers can be 50 or 60 feet away from the tag and still pick up the tag's signals.

Chipless RFID tag: An RFID tag that doesn't depend on a silicon microchip. Some chipless tags use plastic or conductive polymers instead of silicon-based microchips. Other chipless tags use materials that reflect back a portion of the radio waves beamed at them. A computer takes a snapshot of the waves beamed back and uses it like a fingerprint to identify the object with the tag. Companies are experimenting with embedding RF reflecting fibres in paper to prevent unauthorized photocopying of certain documents. Chipless tags that use embedded fibres have one drawback for supply chain uses—only one tag can be read at a time.

Memory: The amount of data that can be stored on the microchip in an RFID tag. It can range from 64 bits to 2 kilobytes or more on passive tags.

Central processing unit: The brains of a computer, which controls all the other parts of the computer.

Air Interface Protocol: The rules that govern how tags and readers communicate.

Agile reader: A generic term that usually refers to an RFID reader that can read tags operating at different frequencies or using different methods of communication between the tags and readers.

It is now important to examine the key features of RFID compared to some of the other forms of identification, notably human readable text, and machine-readable markings (e.g., barcodes) [40].

- Not line of sight: RFID tags do not need to be visible to be read / written.
- Robust: Because they don't need to be visible, they can be encased within rugged materials protecting them from the environment they are being used in. This means they can be used in harsh fluid and chemical environments and rough handling situations.
- Read speed: Tags can be read from significant distances (especially the active variety) and can also be read very quickly. This is especially useful when the items needing to be identified are moving quickly for example on a conveyor.
- Reading multiple items: A number of tagged items can be read at the same time within a RF field. This cannot be done as easily with "visual" identifiers.
- Security: Because tags can be enclosed, they are much more difficult to tamper with. A number of tag types now also come programmed with a unique identifier (Serial Identification) which is guaranteed to be unique throughout the world.
- Programmability: Many tags are read / write capable, rather than read only. This means that information can be written to the tag, perhaps to show that the item being tagged has gone through a particular process, or that it's condition or status

has changed somehow. Or in some instances to store information about the tagged items e.g. the results of a test that it has undergone.

In most applications in which tags are used, it is a combination of the above technical features that justifies their use. The applications described range from the obvious to some very unusual ones. For the purposes of this paper the most interesting are:

Document Tracking: Often the original copies of legal or confidential documents need to be controlled. By employing a smart label tag, and a tag on the actual person, in the form of a card, readers around a building can track documents and reconcile them to the person in possession of them. In addition to this, the documents and the "owner" whereabouts can be monitored at all times. This also can be used as a security feature to ensure that only authorized personnel have access to specific documents [40]. One example of this use is The VeriChip. The VeriChip is an implant the size of a rice grain. It is implanted just above the right tricep, and contains an ID number that can access medical history, including possible drug interactions or diseases [41].

Spare parts for Surgery: When hip surgery is carried out, it involves a number of different parts, all of which are specifically tailored and designed for a particular operation. The parts are supplied in the form of a kit, and must only be used together. Because the parts have to go through a number of manufacturing and sterilizing processes, a label is not suitable. By employing a tag embedded in the part, it can be tracked through various processes, and then all the parts for the kit can be reconciled before being delivered to the hospital. The tag can remain in the part after it is fitted to the patient, so that if it fails at a later date, it can easily be identified [40]**.** Related to this application is The SurgiChip, an external radio frequency identification tag, which affixes like a bandage to patients to ensure that doctors perform the right surgery at the right spot on the right person [42].

Obviously there are several hurdles along the way. Regulators have contended that the use of RFID technology will eventually result in an electronic pedigree that will help wholesalers and retailers rapidly identify, quarantine, and report suspected counterfeit drugs and conduct efficient, targeted recalls [38]. But for an electronic pedigree to work throughout the supply chain, wholesalers and pharmacies must also adopt the expensive RFID technology. FDA officials said that “patient safety and public health” concerns will be the initial incentive for wholesalers and pharmacies to purchase the hardware and software needed to read an RFID tag on a drug label or package. The idea is that as more [RFID] tags get ordered and used by pharmaceutical manufacturers for item-level tagging, there will be a greater need for readers and scanners, leading to an outstanding fall of prices.

The main barrier to implementation historically has been cost justification for a particular application. It is hoped that the broad functionality will allow implementers to use an RFID tag for numerous applications thereby increasing the benefits and improving the return on investment. This, together with continued advancements in RFID technology, will enable it to become more acceptable to a wider user base

Another issue that many are pondering is the radio frequency spectrum on which RFID relies. The issue of getting to global standards is going to be more difficult than it is around bar codes and EDI [electronic data interchange]. Besides, hospitals often have their own radio frequency network, which they use to communicate with nurses and doctors on the floor and update their warehouse management systems (WMS). While hospitals that have updated their networks in the past couple of years probably won't have any problems, companies with older radio frequency networks are going to have interference in the RFID spectrum.

Thus, it should come as no surprise that, to date, one of the biggest disappointments in information technology is the failure to create a nationwide system for patient records. There are a number of reasons for this failure. The Internet and RFID could serve to overcome some obstacles (e.g., communicating and updating records in a standardized and nationwide manner). However, other obstacles remain, such as the concerns about privacy and unauthorized use of information stored in comprehensive databases.

4. Implications for health care management professionals and researchers

Several broad implications for research and practice follow from the proposed co-joint use of RFID and Lean manufacturing principles that can be phrased in question form as follows. Readers would note that given the emerging nature of the topic, the following discussion is conjectural in nature with the aim to identify areas of possibilities and promises:

- What processes are involved in the perception of the ‘‘need’’ for Lean manufacturing and RFID emerging treatments? Who are the responsible for these processes, how do they decide? And how can these decisions be facilitated for maximal effectiveness?

- What is the degree of preference heterogeneity among ‘‘consumers’’ for different treatments (within therapies) and how can providers and payers deal with this heterogeneity when Lean manufacturing principles are implemented together with RFID?

- Does consumer heterogeneity introduce inefficiencies in health care delivery with significant collective costs that the co-joint application of Lean manufacturing and RFID can not deal with?

- Who should control, if at all, the nature, type and amount of medical information stored by RFID devices available to consumers?

- What is the notion and relevance of ‘‘customer orientation’’ in the context of emerging treatments resulting from the co-joint use of Lean manufacturing and RFID? How will it impact the health care environment and delivery systems?

- How can we simultaneously optimise individual and collective outcomes when RFID devices are used to deploy the Lean manufacturing principles?

It is important to acknowledge that emerging treatments offer promises and challenges. But it is unclear for patients how the need for such treatment arises. Sometimes it is even unclear for nurses and doctors, who do not control how the treatment takes hold and generates active pursuit among patients. Because most emerging treatments involve psychological well being and long-term quality-of-life considerations, it is likely that multiple factors representing social, emotional, personal values and physiological considerations fuse along unpredictable pathways to generate motivational energy in patients.

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